

IAEA Safety Standards

for protecting people and the environment

Hazards Associated with Human Induced External Events in Site Evaluation for Nuclear Installations

Specific Safety Guide

No. SSG-79



IAEA

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IAEA SAFETY STANDARDS

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The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA Internet site

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The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

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The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

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Security related publications are issued in the **IAEA Nuclear Security Series**.

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HAZARDS ASSOCIATED
WITH HUMAN INDUCED
EXTERNAL EVENTS
IN SITE EVALUATION FOR
NUCLEAR INSTALLATIONS



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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2023

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FOREWORD

by Rafael Mariano Grossi
Director General

The IAEA's Statute authorizes it to "establish...standards of safety for protection of health and minimization of danger to life and property". These are standards that the IAEA must apply to its own operations, and that States can apply through their national regulations.

The IAEA started its safety standards programme in 1958 and there have been many developments since. As Director General, I am committed to ensuring that the IAEA maintains and improves upon this integrated, comprehensive and consistent set of up to date, user friendly and fit for purpose safety standards of high quality. Their proper application in the use of nuclear science and technology should offer a high level of protection for people and the environment across the world and provide the confidence necessary to allow for the ongoing use of nuclear technology for the benefit of all.

Safety is a national responsibility underpinned by a number of international conventions. The IAEA safety standards form a basis for these legal instruments and serve as a global reference to help parties meet their obligations. While safety standards are not legally binding on Member States, they are widely applied. They have become an indispensable reference point and a common denominator for the vast majority of Member States that have adopted these standards for use in national regulations to enhance safety in nuclear power generation, research reactors and fuel cycle facilities as well as in nuclear applications in medicine, industry, agriculture and research.

The IAEA safety standards are based on the practical experience of its Member States and produced through international consensus. The involvement of the members of the Safety Standards Committees, the Nuclear Security Guidance Committee and the Commission on Safety Standards is particularly important, and I am grateful to all those who contribute their knowledge and expertise to this endeavour.

The IAEA also uses these safety standards when it assists Member States through its review missions and advisory services. This helps Member States in the application of the standards and enables valuable experience and insight to be shared. Feedback from these missions and services, and lessons identified from events and experience in the use and application of the safety standards, are taken into account during their periodic revision.

I believe the IAEA safety standards and their application make an invaluable contribution to ensuring a high level of safety in the use of nuclear technology. I encourage all Member States to promote and apply these standards, and to work with the IAEA to uphold their quality now and in the future.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures¹ have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it

¹ See also publications issued in the IAEA Nuclear Security Series.

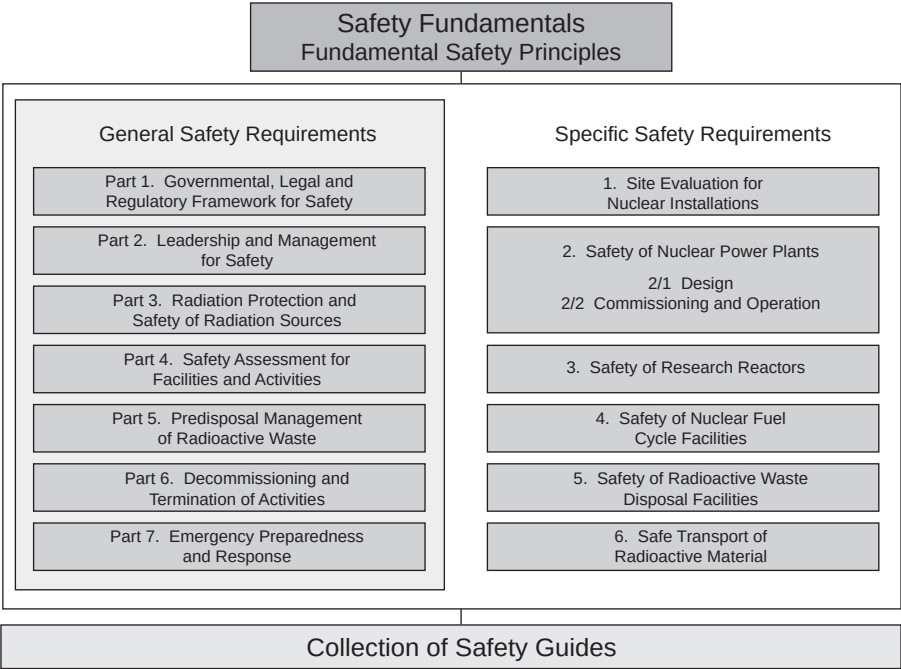


FIG. 1. The long term structure of the IAEA Safety Standards Series.

is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be

used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and five Safety Standards Committees, for emergency preparedness and response (EPReSC) (as of 2016), nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the Safety Standards Committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards.

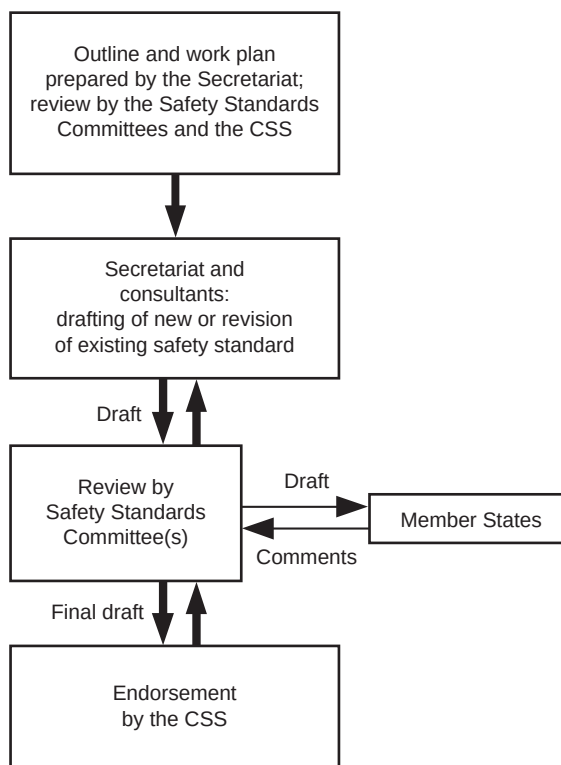


FIG. 2. The process for developing a new safety standard or revising an existing standard.

It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Nuclear Safety and Security Glossary (see <https://www.iaea.org/resources/publications/iaea-nuclear-safety-and-security-glossary>). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

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1. INTRODUCTION

BACKGROUND

1.1. Requirements on evaluating sites for nuclear installations¹ are established in IAEA Safety Standards Series No. SSR-1, Site Evaluation for Nuclear Installations [1]. This Safety Guide provides recommendations on how to meet the requirements established in SSR-1 [1] with regard to the evaluation of hazards associated with human induced external events² (HIEEs).

1.2. This Safety Guide complements other Safety Guides that provide recommendations on site evaluation and design of nuclear installations against external events excluding earthquakes [2–8].

1.3. Over the past two decades, significant new knowledge and experience have been gained in relation to hazards associated with HIEEs. This Safety Guide takes into account the following:

- (a) Recent developments and regulatory requirements for assessing the safety of nuclear installations;
- (b) Progress in practices in Member States relevant to hazards associated with HIEEs;
- (c) A systematic approach to the identification, screening and evaluation of hazards associated with HIEEs;
- (d) Good practice methodologies for evaluation of the hazards arising from the most significant HIEEs.

¹ The term ‘nuclear installation’ includes nuclear power plants; research reactors (including subcritical assemblies and critical assemblies) and any adjoining radioisotope production facilities; spent fuel storage facilities; facilities for the enrichment of uranium; nuclear fuel fabrication facilities; conversion facilities; facilities for the reprocessing of spent fuel; facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities; and nuclear fuel cycle related research and development facilities.

² In this Safety Guide, an external event is an event that originates outside the site for which the operating organization has very limited or no control over its occurrence and whose effects on the nuclear installation should be considered. Such events could be of natural or human induced origin and are identified and selected for design purposes during the site evaluation process. Events originating on the site but outside the buildings important to safety should be treated the same as off-site external events but taking into account the higher level of control over these events (this includes any coupled facilities on the site, such as those to produce hydrogen).

1.4. The terms used in this Safety Guide are to be understood as defined and explained in the IAEA Nuclear Safety and Security Glossary [9]. Explanations of technical terms specific to this Safety Guide are provided in footnotes.

1.5. This Safety Guide supersedes IAEA Safety Standards Series No. NS-G-3.1, External Human Induced Events in Site Evaluation for Nuclear Power Plants³.

OBJECTIVE

1.6. The objective of this Safety Guide is to provide recommendations on evaluation of hazards associated with HIEEs that could affect the safety of nuclear installations, in order to meet the requirements established in SSR-1 [1], in particular Requirements 6–9, 14 and 24. These hazards need to be considered in the selection and evaluation of sites for nuclear installations, in the design of new nuclear installations and in the operation of existing nuclear installations.

1.7. This Safety Guide is intended for use by organizations involved in the identification, screening, analysis, evaluation and review of hazards associated with HIEEs, and in the provision of technical support for these activities. It is also intended for use by regulatory bodies for establishing regulatory guides on the evaluation of hazards associated with HIEEs.

SCOPE

1.8. The recommendations in this Safety Guide are intended to be used for the evaluation of hazards associated with HIEEs for nuclear installations. The approach to evaluating these hazards and the use of these evaluations need to be planned and implemented in a systematic way. This process can be divided into the following steps:

- Step 1: Identification and screening of sources of hazards;
- Step 2: Evaluation of hazards and characterization of loading conditions;
- Step 3: Design and evaluation of structures, systems and components;
- Step 4: Performance, assessment and acceptance criteria;
- Step 5: Response of the operating organization to potential HIEEs.

³ INTERNATIONAL ATOMIC ENERGY AGENCY, External Human Induced Events in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.1, IAEA, Vienna (2002).

This Safety Guide considers steps 1 and 2. Steps 3 and 4 are addressed in IAEA Safety Standards Series No. SSG-68, Design of Nuclear Installations Against External Events Excluding Earthquakes [7], and step 5 is addressed in IAEA Safety Standards Series No. SSG-77, Protection Against Internal and External Hazards in the Operation of Nuclear Power Plants [8]. These steps are closely linked, and the needs of each step should be recognized in other steps, especially at the interfaces between steps where the outputs from earlier steps inform and provide input data to later steps.

1.9. In this Safety Guide, HIEEs are grouped into following event categories:

- External release of hazardous material;
- External explosions;
- External fire;
- Aircraft crash;
- External transport events excluding aircraft crashes;
- Other HIEEs (e.g. ground subsidence, electromagnetic interference).

1.10. This Safety Guide includes recommendations on consequential hazards arising from HIEEs, for example an aircraft fuel fire following an aircraft impact. However, it does not address combinations of hazards. Recommendations on hazard combinations are provided in SSG-68 [7].

1.11. This Safety Guide addresses a range of types of nuclear installation (see footnote 1). Many of the recommendations were originally developed for nuclear power plants, and such recommendations need to be applied to other nuclear installations through a graded approach. The direction of this graded approach is to start with recommendations relating to nuclear power plants and, if appropriate, to adjust these recommendations to installations with lesser radiological consequences. If a graded approach is not taken, the recommendations relating to nuclear power plants are to be applied.

1.12. This Safety Guide is mainly focused on the evaluation of the site for a new nuclear installation. However, the recommendations are also applicable in the

re-evaluation of sites of existing nuclear installations⁴ and in the periodic safety reviews of such installations. As such, the recommendations in this Safety Guide apply to all stages of the lifetime of a nuclear installation, from site selection to decommissioning.

1.13. This Safety Guide addresses site evaluation for sites on which multiple nuclear installations are located and for coupled facilities (if any) on the same site or on adjacent sites.

1.14. The external human induced events considered in this Safety Guide are of accidental origin. Other human induced events are outside the scope of this Safety Guide, although these will be a consideration in planning the mitigation of and response to such events. Considerations relating to the nuclear security of nuclear installations against malicious activities (i.e. deliberate acts of sabotage) by third parties are outside the scope of this Safety Guide. However, the methods described herein for the evaluation of hazards associated with HIEEs of accidental origin may also be applied in the evaluation of the effects of malicious acts. Guidance on nuclear security is provided in the IAEA Nuclear Security Series [10–15]. Due consideration should be given to the sensitivity of the information on HIEEs from a nuclear security perspective. Such information should be handled carefully in cooperation with nuclear security specialists.

STRUCTURE

1.15. Section 2 provides recommendations on the evaluation of hazards associated with HIEEs for nuclear installations. Section 3 provides recommendations on the identification and screening of sources of HIEEs and the evaluation of the hazards associated with these HIEEs. Section 4 provides recommendations on data collection and investigations. Sections 5–10 provide recommendations on hazard evaluations associated with the different event categories described in para. 1.9. Section 11 provides recommendations on applying a graded approach to the evaluation of hazards associated with HIEEs for nuclear installations other than

⁴ For the purposes of this Safety Guide, existing nuclear installations are those installations that are (i) at the operational stage (including long term operation and extended temporary shutdown periods); (ii) at a pre-operational stage for which the construction of structures, the manufacturing, installation and/or assembly of components and systems, and commissioning activities are significantly advanced or fully completed; or (iii) at a temporary or permanent shutdown stage with nuclear fuel still within the facility (i.e. in the core, spent fuel pool, on-site waste storage).

nuclear power plants. Section 12 provides recommendations on the application of the management system to the evaluation of hazards associated with HIEEs. The Appendix provides tables for use in evaluating such hazards. Typical generic screening distance values are given in the Annex.

2. GENERAL RECOMMENDATIONS ON THE EVALUATION OF HUMAN INDUCED EXTERNAL EVENTS

SAFETY REQUIREMENTS FOR THE EVALUATION OF HUMAN INDUCED EXTERNAL EVENTS

2.1. Requirements 6–9, 14 and 24 of SSR-1 [1] are all relevant to the evaluation of hazards associated with HIEEs for nuclear installations, and these requirements are reproduced in paras 2.2–2.7 for convenience.

2.2. Requirement 6 of SSR-1 [1] states that **“Potential external hazards associated with natural phenomena, human induced events and human activities that could affect the region shall be identified through a screening process.”**

2.3. Requirement 7 of SSR-1 [1] states that **“The impact of natural and human induced external hazards on the safety of the nuclear installation shall be evaluated over the lifetime of the nuclear installation.”**

2.4. Requirement 8 of SSR-1 [1] states that **“If the projected design of the nuclear installation is not able to safely withstand the impact of natural and human induced external hazards, the need for site protection measures shall be evaluated.”**

2.5. Requirement 9 of SSR-1 [1] states that **“The site evaluation shall consider the potential for natural and human induced external hazards to affect multiple nuclear installations on the same site as well as on adjacent sites.”**

2.6. Requirement 14 of SSR-1 [1] states:

“The data necessary to perform an assessment of natural and human induced external hazards and to assess both the impact of the environment on the safety of the nuclear installation and the impact of the nuclear installation on people and the environment shall be collected.”

2.7. Requirement 24 of SSR-1 [1] states that **“The hazards associated with human induced events on the site or in the region shall be evaluated.”** Paragraphs 2.8–2.12 reproduce the supporting requirements to Requirement 24.

2.8. Paragraph 5.33 of SSR-1 [1] states:

“Human induced events to be addressed shall include, but shall not be limited to:

- (a) Events associated with nearby land, river, sea or air transport (e.g. collisions and explosions);
- (b) Fire, explosions, missile generation and releases of hazardous gases from industrial facilities near the site;
- (c) Electromagnetic interference.”

2.9. Paragraph 5.34 of SSR-1 [1] states that “Human activities that might influence the type or severity of natural hazards, such as resource extraction or other significant re-contouring of land or water or reservoir induced seismicity, shall be considered.”

2.10. Paragraph 5.35 of SSR-1 [1] states that “The potential for accidental aircraft crashes on the site shall be assessed with account taken, to the extent practicable, of potential changes in future air traffic and aircraft characteristics.”

2.11. Paragraph 5.36 of SSR-1 [1] states:

“Current or foreseeable activities in the region surrounding the site that involve the handling, processing, transport and/or storage of chemicals having a potential for explosions or for producing gas clouds capable of deflagration or detonation shall be addressed.”

2.12. Paragraph 5.37 of SSR-1 [1] states:

“Hazards associated with chemical explosions or other releases shall be expressed in terms of heat, overpressure and toxicity (if applicable), with account taken of the effect of distance and non-favourable combinations of atmospheric conditions at the site. In addition, the potential effects of such events on site workers shall be evaluated.”

2.13. The requirements equivalent to those listed in paras 2.2–2.12 for research reactors and for nuclear fuel cycle facilities are provided in IAEA Safety Standards Series Nos SSR-3, Safety of Research Reactors [16] and SSR-4, Safety of Nuclear Fuel Cycle Facilities [17], respectively.

GENERAL CONSIDERATIONS FOR THE EVALUATION OF HUMAN INDUCED EXTERNAL EVENTS

2.14. HIEEs are caused by people; the way people act creates an environment in which hazardous events can occur and propagate. An important consideration is to recognize the possibility of an event and seek data from experience to support judgements on which of these possible events are likely to be significant and on how frequently they are likely to occur. HIEEs include direct human action (e.g. exceeding a safe speed limit or energizing an incorrect item of equipment), indirect human action (e.g. substandard design of equipment, poor maintenance practice), and errors of commission and omission.

2.15. Potential sources of HIEEs are classified as stationary or mobile and both should be considered. They are defined as follows:

- (a) Stationary sources of HIEEs are those that involve the handling, processing or storage of potentially hazardous substances such as explosive, flammable, corrosive, toxic or radioactive materials, and for which the location of the initiating mechanism (explosion centre, point of release of flammable or toxic gases) is fixed, such as chemical plants, oil refineries, storage depots and other nuclear facilities at the same or a nearby site. Structures such as dams that control large volumes of water are also stationary sources of HIEEs, for which recommendations are provided in IAEA Safety Standards Series No. SSG-18, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations [3].
- (b) Mobile sources of HIEEs are those for which the location of the initiating mechanism is not totally constrained, such as the transport or movement of

hazardous material or potential projectiles (e.g. by road, rail, waterways, air, pipelines). In such cases, an accidental explosion or a release of hazardous material might occur anywhere along a road, route or pipeline.

2.16. A region with a nuclear installation site is required to be examined for facilities and human activities that have the potential to endanger the nuclear installation over its entire lifetime (see para. 4.12 of SSR-1 [1]). As such, each potential source of HIEEs is required to be identified and assessed to determine the potential interactions with the nuclear installation.

2.17. Paragraph 4.14 of SSR-1 [1] states that “The size of the region to be investigated shall be defined for each of the natural and human induced external hazards.” The size of the region to be investigated depends on the type of HIEE source and will range from a few kilometres for fire to tens of kilometres for aircraft crashes and bombing ranges, for example. The possibility that, in specific situations, a minor event might lead to severe effects should be taken into account.

2.18. Some of the hazards associated with HIEEs are more widespread than others. These effects could affect the nuclear installation’s off-site facilities as well as operating personnel and items important to safety on the site, such as by affecting the availability of evacuation routes (e.g. the site might lose links to safe areas in the region), the effective implementation of emergency procedures (e.g. access by operating personnel could be impaired), and the availability of the external power grid and the ultimate heat sink (see also Requirement 11 of SSR-1 [1]). Special attention should be given to understanding the various levels of defence in depth that might be challenged by such events.

2.19. Paragraph 4.15 of SSR-1 [1] states that “The site and the region shall be studied to evaluate the present and foreseeable future characteristics that could have an impact on the safety of the nuclear installation.” Similarly, Requirement 10 of SSR-1 [1] states that **“The external hazards and the site characteristics shall be assessed in terms of their potential for changing over time and the potential impact of these changes shall be evaluated.”** New sources of HIEEs can appear and existing sources can evolve rapidly. Therefore, a prognosis should be made for possible regional development over the anticipated lifetime of the nuclear installation, with account taken of the degree of administrative control that could realistically be exercised over activities in the region. In this respect, allowance should be made for the fact that technologies in the chemical and petrochemical industries, as well as traffic densities, may evolve rapidly.

2.20. HIEEs initiated at a source might eventually result in different hazards at a nuclear installation site following an interacting mechanism⁵. A number of potential HIEE sources (e.g. a chemical process site) are presumed to exist around a nuclear installation; each source is capable of one or more events (e.g. a facility failure causing an explosion and releasing stored process gas), and each event might create one or more hazardous conditions (e.g. explosion pressure wave, release of toxic gas) with the potential to challenge safety at a nearby nuclear installation. In principle, it is necessary to perform a hazard analysis of each HIEE scenario; however, only a small subset of these scenarios are likely to represent a credible risk to safety. In order to make the overall HIEE analysis traceable, this Safety Guide includes recommendations on identification and screening to ensure that only those sequences that are significant to the safety of the nuclear installation are considered throughout the entire process.

2.21. In general, there are three types of protection against HIEEs for a nuclear installation: (i) protection through a robust design of the structures, systems and components important to safety; (ii) protection through the provision of site protection measures such as sufficient distance and barriers; and (iii) protection through administrative measures such as no-fly zones and restrictions on the transport of hazardous material in the vicinity of the site. Administrative measures are generally the least reliable means of protection and should be considered as complementing the first two types of protection.

2.22. Paragraph 4.19 of SSR-1 [1] states:

“External hazards that are not excluded by the screening process shall be evaluated and then used in establishing the site specific design parameters and in the re-evaluation of the site, in accordance with the significance of these hazards to the safety of the nuclear installation.”

A satisfactory engineering solution should be implemented to protect against those HIEEs that have not otherwise been excluded from further consideration using the screening process presented in Section 3. Appropriate administrative actions should be taken in the case of an existing nuclear installation in which satisfactory engineering solutions are not considered reasonably practicable.

⁵ To further illustrate the concept of ‘interacting mechanism’, examples of HIEE event categories, generic screening distance values, identification of sources of HIEEs, potential HIEEs at these sources, possible hazards at a site, load characterization parameters and possible consequences at a nuclear installation site are provided in the Appendix and in the Annex.

2.23. Lack of confidence in the quality of the available data (e.g. in terms of their accuracy, applicability, completeness or quantity) may preclude the use of complex analysis techniques to characterize some HIEEs, either at the screening step or in the subsequent hazard evaluation. In such cases, a pragmatic approach based on engineering judgement should be taken, always ensuring that such judgements are demonstrably conservative (see also para. 4.8 of SSR-1 [1]). Recommendations on data collection are provided in Section 4.

2.24. Hazards associated with HIEEs in the region of nuclear installations are required to be periodically re-evaluated within the framework of the periodic safety reviews of nuclear installations (see Requirement 29 of SSR-1 [1]).

3. IDENTIFICATION OF SOURCES OF HUMAN INDUCED EXTERNAL EVENTS, SCREENING AND EVALUATION METHODS

GENERAL PROCEDURE

3.1. The evaluation of hazards associated with HIEEs involves a multistep approach (see para. 1.8). In the first step, sources of HIEEs should be identified on the basis of available data, followed by collection of data for the relevant regions. Screening should then be conducted on the basis of the established distance and probability criteria. In the next step, detailed evaluation of screened-in hazards should be conducted. The identification of sources of HIEEs should initially be performed using limited, easily accessible data, and should then be refined as more data, knowledge and information regarding how the HIEEs might affect the site or nuclear installation become available. Recommendations on the process of identification, screening and detailed evaluation of each source of HIEEs are provided in this section and are shown in Fig. 1.

IDENTIFICATION AND SCREENING OF SOURCES OF HUMAN INDUCED EXTERNAL EVENTS

3.2. The screening distance value is the distance from the nuclear installation site beyond which a hazard from an HIEE is considered insignificant to the safety of the nuclear installation. The screening distance value is a simple and conservative

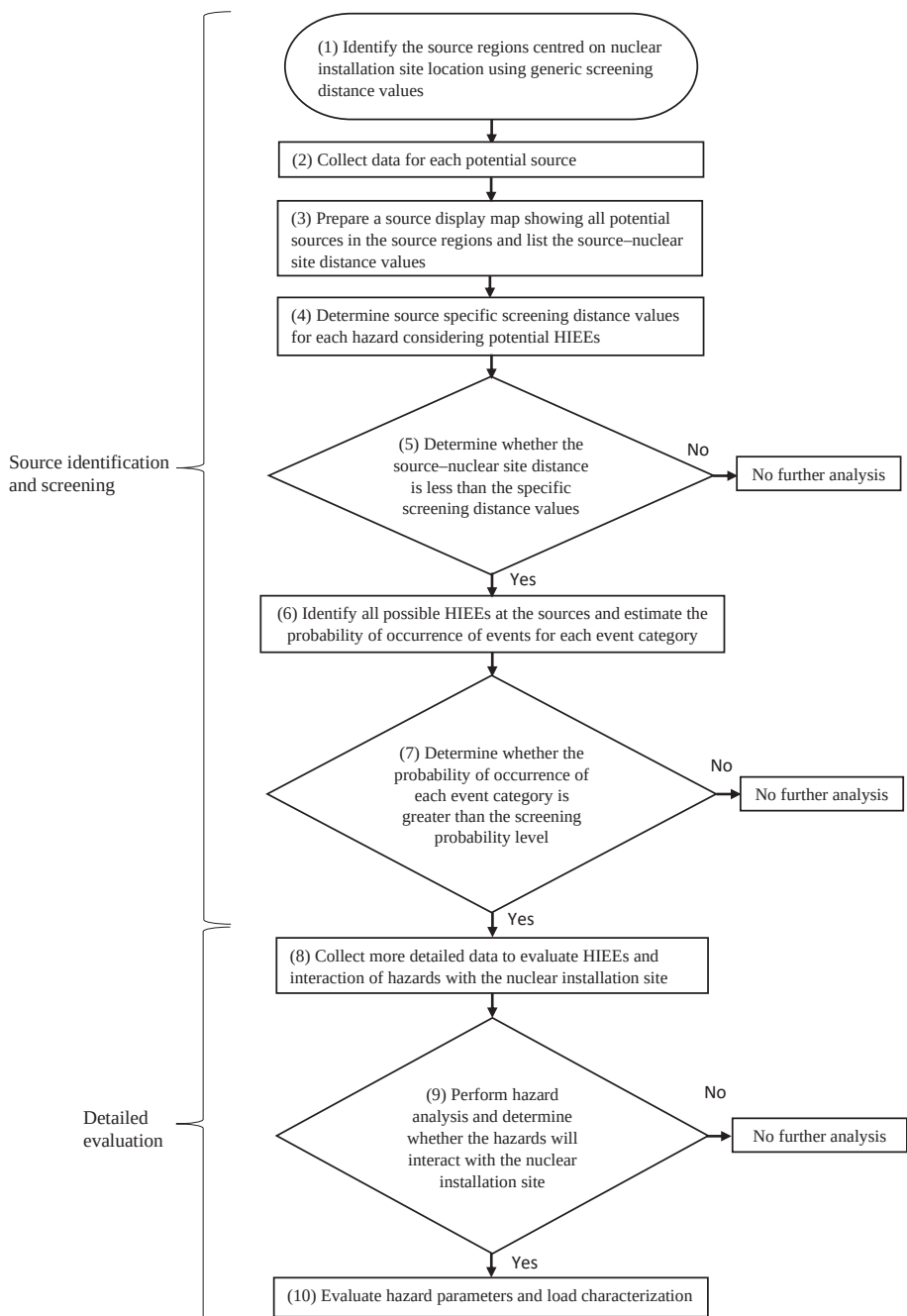


FIG. 1. Process for source identification, screening, and detailed evaluation for each type of source of HIEEs.

tool linked to the potential hazard that ignores any additional factors such as the mass involved or typical atmospheric conditions. For some sources, a simple deterministic study based on information on the location and characteristics of the source may be enough to show that no interaction takes place.

3.3. To initiate the evaluation process, source regions centred on the nuclear installation site should be identified (see box 1 in Fig. 1) on the basis of generic screening distance values for different event categories (see Table A–1 in the Annex). These generic screening distance values are typical values used by some States for large nuclear power plants with standardized designs. For other types of nuclear installation, these values should be reviewed and revised accordingly. These values should also be revised if the nuclear installation design and layout present any specific potential weakness with respect to HIEEs.

3.4. Local topography and regional and local meteorological effects may significantly modify the initially assumed safe distances. If there are any peculiar site conditions or significant specific hazards, the sources of HIEEs should be considered in the next evaluation step even if they were screened out in the previous evaluation step with respect to distance. Safe distances from potential sources differ greatly, for example for a chemical plant located close to a nuclear installation that is well protected by hills compared with a nuclear installation located farther away in a flat area with predominant winds blowing towards the site.

3.5. All stationary and mobile sources of potential HIEEs in the source regions should be identified, and data for these sources (e.g. source type, distance, potential events) should be collected (see box 2 in Fig. 1). Recommendations on data collection and investigations are provided in Section 4.

3.6. A source display map showing all potential sources of HIEEs (both present and foreseeable sources) should be prepared, and these sources should be listed together with the distances from the nuclear installation site (see box 3 in Fig. 1). Any uncertainties related to these sources should be estimated.

3.7. For each type of effect that could arise from an HIEE, the acceptable loading limit for the nuclear installation design should be considered.

3.8. A specific screening distance value for each source of an HIEE (stationary and mobile) should be determined by simple calculations using source specific data and considering local site conditions. The determination of the specific screening distance value should take into consideration the severity and extent of the event, including relevant uncertainties, as well as the expected characteristics

of the nuclear installation to be located at the site. For the early stages of the siting process, these characteristics may be assumed to be those corresponding to the standard nuclear installation design.

3.9. HIEEs might potentially generate different types of hazard (e.g. an event at a chemical plant might produce toxic gas and a pressure wave) at the nuclear installation site (see box 4 in Fig. 1), as explained in para. 2.20. The specific screening distance value of each hazard will be quite different as a gas vapour cloud may travel a much longer distance than the pressure wave. In this case, the screening distance value of this source should be taken as the longer distance.

3.10. After considering potential future changes in source characteristics (see para. 2.19) and associated uncertainties related to distances and intensities, if the nuclear installation site is beyond all specific screening distance values for the specific source of HIEEs, no further analysis is necessary (see box 5 in Fig. 1).

3.11. For sources of HIEEs that generate effects of the same nature, a further screening should be performed. This screening should be based on an enveloping criterion and should exclude those sources that generate events that are enveloped by other sources of HIEEs, even if the site is within the specific screening distance values for these sources. However, it should be ensured that the enveloped sources are considered if and when the event frequency is estimated. Care is also needed to avoid interpreting this enveloping as a reduction in the number of events that could affect the nuclear installation, and thus a reduction in the event probability.

3.12. If the nuclear installation site is within one or more specific screening distance values, relevant HIEEs are required to be identified and the probability of occurrence of these events is required to be estimated (see box 6 in Fig. 1) (see Requirement 6 of SSR-1 [1]).

3.13. The probabilistic screening should be done on the total occurrence of an event category. If the probability of occurrence is less than the specified screening probability level⁶, no further analysis is necessary for that source (see box 7 in

⁶ The screening probability level is based on the probability of the occurrence of events and is defined as the limiting value of the annual probability of occurrence of events with potential radiological consequences. In some States, a probability of 10^{-7} per reactor-year is used in the design of new facilities as one acceptable limit on the probability value for interacting events with serious radiological consequences, and this is considered a conservative value for the screening probability level if applied to all events of the same type (e.g. all aircraft crashes, all explosions).

Fig. 1). The screening probability level should be chosen such that the radiation risk associated with hazards is acceptably low. Uncertainties should be considered in calculating the probabilities of occurrence of HIEEs in probabilistic screening.

DETAILED EVALUATION OF HUMAN INDUCED EXTERNAL HAZARDS INCLUDING HAZARD PARAMETERS AND LOAD CHARACTERIZATION

3.14. If the probability of occurrence of the HIEEs under consideration is greater than the specified screening probability level, a detailed evaluation should be performed. For this purpose, more detailed data should be collected to evaluate the events and the interaction of the hazards with the nuclear installation site (see box 8 in Fig. 1).

3.15. Hazard analysis should be performed to check whether hazards associated with HIEEs will interact⁷ with the nuclear installation site. If the hazard analysis results show that the hazards will not interact with the nuclear installation site, no further analysis is necessary (see box 9 in Fig. 1).

3.16. If any of the hazards can interact with the nuclear installation site, a detailed hazard evaluation should be performed and hazard parameters and load characterization should be established (see box 10 in Fig. 1). Tables 3 and 4 in the Appendix list the common hazards likely to be encountered are listed and the relevant type of hazard and characterization parameters are indicated in each case.

3.17. If applicable, a second level of screening based on the specific characteristics of the site and the nuclear installation can be implemented. Typical screening parameters to be applied are probability, magnitude and distance of the HIEE, and on-site characteristics (e.g. design conditions, zones of influence). Details are provided in Ref. [18].

3.18. This process should be repeated for each source of HIEEs. Further recommendations on the application of the process for each event category are provided in Sections 5–10.

⁷ Interact means that a hazard will reach the nuclear installation site, as determined by hazard analysis.

4. DATA COLLECTION AND INVESTIGATIONS REGARDING HUMAN INDUCED EXTERNAL EVENTS

4.1. The collection of data regarding potential sources of HIEEs should involve the collection of site specific data as well as generic data on events due to similar sources worldwide, as such events might or might not have occurred around nuclear installation sites. It should be recognized that such data might not be readily available for reasons of confidentiality.

4.2. Individual States have different methods of data collection. The recommendations in this section provide a general approach for data and information collection that should be adapted to the specific legal framework of the State in which the nuclear installation site is situated.

DATA AND INFORMATION COLLECTION RESOURCES FOR HUMAN INDUCED EXTERNAL EVENTS

4.3. Requirements for data and information collection are established in Requirement 14 of SSR-1 [1]. The following is a list of the most relevant and important data and information collection resources:

- (a) Organizations and individuals responsible for potential sources of HIEEs;
- (b) Local and national government organizations with an interest in controlling, licensing or authorizing sources of HIEEs, including relevant authorities involved in the regulation of health and safety;
- (c) Professional institutions and organizations;
- (d) Regional data and relevant documents from government organizations, supplemented by generic data from the literature;
- (e) Experience of good practice in defining hazards from similar sources that are potentially significant to nuclear installations elsewhere;
- (f) Other sources of data such as local maps, published reports and public records relevant to activities around the nuclear installation site and which are likely to be relevant to HIEEs;
- (g) Public and private agencies and individuals (in addition to those identified above) likely to be knowledgeable about the characteristics of the local area.

Seeking advice from organizations and individuals responsible for potential sources of human induced external events

4.4. The most important data and information resource regarding the hazards arising from a source of HIEEs is the operating organization of the source itself. Contact with the operating organization should be made at an early stage, with the objective of building a constructive relationship to facilitate information exchange. It is important to remember that while the source (e.g. an industrial site) presents a portfolio of hazards to the nuclear installation site, the nuclear installation also presents a portfolio of hazards to the source of HIEEs.

4.5. The operating organization of the source of HIEEs is likely to have the best understanding of the processes and hazards presented by its activities. The operating organization may already have well developed data and safety analyses that could be made available and almost certainly will be the best source of expert advice on its activities.

4.6. The operating organization of the source of HIEEs is likely to be subject to health and safety regulation. The appropriate regulatory bodies should be consulted for advice and should be made aware of the potential development of the nuclear installation and the likely hazards it might pose to industrial sites in the region. The operating organization of the nuclear installation should ensure that it provides a clear description of the aim and scope of the data request in order to ensure the quality and accuracy of the gathered data.

4.7. The information received from operating organizations of the sources of HIEEs should be verified and validated and, wherever possible, also be validated by an independent reviewer.

Regional emergency plans

4.8. Industrial sites that could impose hazards on a nearby nuclear installation are likely to also expose the local population to the same hazards. Such sites should be expected to provide sufficient data to enable national or local government authorities (as appropriate) to prepare regional emergency plans. Such government authorities may have useful data on regional sources of HIEEs that should also be collected.

Land use planning

4.9. Many States have well developed land use planning legislation that will apply to any new or proposed nuclear or conventional development; this same legislation is also likely to have been applied to any existing sources of HIEEs in the region at the time of their planning and development. An objective of land use planning legislation is usually to ensure that all national and local government agencies requiring knowledge of a planned hazardous site are able to obtain the information they need at an appropriate stage before and during the development process (including the data needed for the development of regional emergency plans) and have the opportunity to provide advice during the planning process on any public safety issues raised by the development. A further objective is to provide a platform for informing those members of the public (including the operating organizations of other industrial sites) who might be affected by the development and for facilitating public comment. The government planning authority for the region surrounding the nuclear installation may be able to provide useful information on sources of HIEEs. The degree to which land use planning legislation considers subsurface land use differs between States. The potential for subsurface human activities to change the external hazards for a nuclear installation should be considered under the national legal framework (see also para. 5.34 of SSR-1 [1]).

4.10. Consideration should be given to sources of HIEEs that are planned or under commercial development, watercourse developments such as dams, and marine developments such as new or modified ports and harbours (and associated changes to sea lanes) and barrages, as well as to any sources of HIEEs that are undergoing decommissioning. Such developments might lead to additional sources of hazards in the future and potentially to an increased risk of radiological consequences over the lifetime of the nuclear installation. Also important are developments that could change the population distribution in the region around the nuclear installation, since this might have implications for emergency preparedness and response.

4.11. Particular consideration should be given to the possibility that new sources of HIEEs could present hazards that are the same as hazards from existing sources that are currently screened out. The potential for adverse interactions between any new hazards and those from existing sources should also be considered (e.g. the possibility of fire spreading from a new source of HIEEs to an existing source). In either case, it may be necessary to provide additional protection and/or mitigation measures either at the nuclear installation site or as part of the new development. The progression of industrial development should be closely tracked by maintaining a continuous liaison with the local authorities.